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ABSTRACT

The Interactive Multimedia Distance Learning (IMDL) project evolved from discussions between Rensselaer Polytechnic Institute (RPI) (New York) and AT&T about how to use the strengths of AT&T's Bell Laboratories and RPI's Anderson Center for Innovation in Undergraduate Education (CIUE) to collaborate on a project in the domain of computers and communications. The project involved redesigning a course from AT&T's University of Sales Excellence (USE). The "Virtual Classroom" prototyped by RPI and AT&T is a student-centered model that combines video teleconferencing with real time, synchronous data communications for sharing of computer generated examples, and data. The level of interaction is high; the environment brings instructors and students from remote sites together in a desktop computer environment. Teachers may write comments on students' work and use text, graphics, animations, videos, sounds or live demonstrations to present curriculum content to students. Students may work with exercises from the teacher in local (desktop) or shared ace (the blackboard) and collaborate on exercises with other studen s; they can also alert the teacher that they would like to ask a question. The IMDL environment was tested, and participant reactions were grouped into two areas. One group of found the experience enjoyable and noted potential to improve others modes of instructional delivery. The other group described their intimidation by the technology employed in delivering the course. (AEF)

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Interactive MultiMedia Distance Learning (IMDL) The Prototype of the Virtual Classroom

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Abstract: This paper describes a collaborative project between Rensselaer's CIUE and AT&T's Bell Laboratories to create a prototype of an interactive, distributed multimedia desktop classroom environment. The prototype is called a "Virtual Classroom" because it brings instructors and students from remote sites together in a desktop computer environment that includes multi-point video, audio and multimedia data communication. This environment fosters real interactivity between students and instructors and among students who may be located at sites anywhere in the world.

Introduction

Interactive Multimedia Distance Learning (IMDL) is the model for the "Virtual Classroom" prototyped by Rensselaer and AT&T. The IMDL environment model combines the rich communication capabilities of 2-way video teleconferencing with real time, synchronous data communications for sharing of computer generated examples and data. The level of interaction is quite high and the environment offers the possibility of sharing between teacher and students and students with their peers.

The visual and auditory communication is enabled by multi-point video conferencing over the AT&T Digital Network, using Integrated Services Digital Network (ISDN) Primary Rate Interface (PRI) facilities. The 2 way video communication is integrated into the desktop computer environment via a video window on the computer screen. Instructors, and students, may control MS Windows-based applications on the other participants' workstations. The shared applications may include instructional applications, text and graphics screens, animations, video clips and audio clips used to enhance learning and collaboration.

CIUE is a research and development center at Rensselaer dedicated to the advancement of innovative undergraduate education. The CIUE is particularly interested in the applications of technology and cognitive science in education. We also act in a leadership role for the implementation of research in the classrooms of our campus and other institutions internationally.

AT&T Bell Laboratories is the Research and Development Center for AT&T and is an international leader in research in telecommunications and computing.

Learning in the Virtual Classroom

Let's imagine for a moment that you are a mother and a returning student in an engineering school. You are taking classes at home because you have family responsibilities. You have spent the morning doing library research at your home computer and now it's time for Physics class.....

You save your journal articles on your local disk drive and then click on an icon on your screen to sign on for your class. After entering your name and ID information, a video window appears on your screen where you see the instructor giving announcements about today's class. "Just in time," you exclaim, as you enlarge the video

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window and turn up the volume in order to see and hear better. The instructor then begins to greet each student individually and switches the focus of the session to each location so that everyone may see and hear each student saying hello. You recognize other students who are participating in this class from home and on-campus locations.

The class begins with the instructor discussing the concept of acceleration. The instructor then explains a demonstration of gravitational acceleration that she is about to perform. You decide that this looks important and turn on your video capturing function in order to view the demonstration again at a later time. After performing the demonstration, the instructor then sends each student a copy of the demonstration, which is a digitized video clip of an assistant dropping a ball. Now the instructor begins to guide you through the process of graphing the position of the ball, stepping through the video clip frame by frame; writing notes on your screen to point out important points.

One of the steps of the exercise makes absolutely no sense to you and you send the instructor a question message. Apparently, you are not the only student confused. The instructor stops the session and acknowledges that she has received a lot of questions all of a sudden. The instructor then turns the focus of the class to you and you ask your question and point out on the screen where you got confused. After the instructor clears up the point of confusion, you add some notes to the screen for later use. The instructor then poses several problems for the class to solve on their own, using the data collected from the graphing exercise and the computational tools that you use every day for all your classes. After you perform the required analyses, you send the file to the instructor for review. The instructor then displays each student's work and writes comments about their methods.....

This scenario may sound futuristic; however, it is based on the tools and capabilities of the IMDL prototype we have developed. The actions described in the scenario are detailed further below to show how they enable an efficient learning environment. The technical capabilities required for this kind of interaction to occur at home locations are rapidly being deployed by telephone and cable companies. Refer to the section entitled, "How Will Technological Advances Effect IMDL?" for further discussion of this issue.

We are attempting to recreate the "social construct" of the classroom. In order to recreate the traditional classroom, we must offer the capability to the participants to perform the actions that they perform in traditional classrooms. We will not attempt to discuss all the teaching strategies that educators have used, or how they may be implemented in the IMDL environment. However, in the next section we will discuss a few of the actions common to most teaching strategies and how we have implemented them in the IMDL environment.

Interactions in the Virtual Classroom

In traditional classrooms, teachers may create exercises for students to work with in a shared space (the blackboard). Teachers may also write comments on student's work. In addition, teachers use text, graphics, animations, videos, sounds or live demonstrations to present curriculum content to students. Students may work with exercises from the teacher in local (on desktop) or shared space (the blackboard). They may also collaborate on exercises with other students. Also, students may alert the teacher that they would like to ask a question.

Event Sharing

In the IMDL environment teachers and students share a workspace of identical instructional software applications. One participants' workstation is configured to be the leader of the session and all the other workstations follow the actions of the leader. The actions may be to present screens of text or graphics, play animations, video or audio clips, or simulate a phenomenon. The leader may pass the focus to a student workstation. When this happens, the student controls the flow of the shared events. The focus for video and audio may also be passed to the student, so that everyone may see and hear the student ask their question. However, in our model only the instructor may pass the focus of the session and only the instructor may take it away. This instructor control is important in order to maintain class structure in the distributed classroom.

Each workstation may work independently, as well, both during the session and on their own time, with all the instructional software applications. The students may want to research something that has just been discussed in class, or may need to perform a calculation to answer a question posed in class. These actions may be performed with local software applications.

Annotation

The participant whose workstation is designated the leader may draw on their own screen. These drawings will also appear on the other participants' screens. This feature of IMDL allows the leader to add notations to the material being presented, adding meaning and emphasizing the important points.

Hand Raising

The students may send a message to the instructor's workstation, letting the instructor know that they have a question. The instructor will see the message coming in and may choose to acknowledge the question or to respond at a more convenient time. When the instructor acknowledges the student, then the instructor may pass the focus of the session to the student (as we discussed in the section above on Event Sharing). Our testing has shown that this structured approach to teacher/student dialogs is helpful because it helps each participant to be sure who has the focus and who is sharing information with the other participants.

Instructor Pointer

The teacher may move a pointer around the student screens to direct their attention to the important points in the information displays. The teacher does not need to verbally describe the position of the point of interest. This shared pointer works similarly to the pointers used in traditional classrooms. The students also have their own pointers (the MS Windows mouse cursor) that they have control over, independent of the teacher pointer.

Implications of Learning Theory

At the core of any discussion of education is the fact that education is a communication process. Regardless of the model of pedagogy that one works with; communication between instructor and student and among students is central to the process. New developments in theories of learning make communications even more important to the process. We bring to this project the benefit of a great deal of education research. What this modern research is telling us may be summarized by the following points:

Teachers are not simply the delivery mechanisms of the content of a curriculum. A great lecturer can be very motivational, but research has demonstrated that the lecture is not efficient in stimulating student learning. (Laws,1991; Hestenes,et al,1992; Redish,Wilson, McDaniel,1992) The model we work with is one of a teacher as "coach" of their students' learning process (Pea,1992; Laws,1991). The teacher is actively involved in helping the students construct their own understanding of the curriculum material. This activity is best carried out when the teacher and students have available to them a rich set of communication tools to enable the coaching process.

Learning is a highly interactive process. Students bring with them a highly developed set of preconceptions and beliefs. The teacher and student become involved in a learning "conversation" in which both parties clarify messages, test for understanding, compare and contrast with previous understandings and are both transformed by the experience Pea (1992). The learning "conversation" is a communication process in which meanings are negotiated to student understanding of curriculum material. What we seek to provide are a rich set of communication tools to help foster these interactions between teachers and students.

Education has been criticized as an endeavor that is too far removed from the context of its meaning. If learning is to be viewed as a process that has meaning beyond the classroom; the students must be able to reach beyond the classroom. Practitioners from the field of study can be brought to the classroom. However, this is not always possible, or practical. There have been several excellent examples of providing electronic mail and

conferencing between students and practitioners. The "National Geographic Service Kids' Network", Julyan (1991), allowed students to collaborate with other students and scientists on a study of acid rain. The "Collaborative Visualization Project", Pea (1992) , a new project now being implemented, will allow students to collaborate with other students and access on-line data resources and scientists in a Project Enhanced Science Learning-at-a-distance approach. These projects each are important steps in bringing the student into the communities of practitioners.

Learning can be enhanced by providing students with access to powerful computing tools that can allow the student to interact with real data and solve open-ended problems. Learning-by-doing has been shown to be a successful pedagogical model to enable students to solve real world problems. (Laws, 1991; Redish, Wilson, McDaniel,1992) This learner-centered view allows the student to start with what they know and build their own understanding of the subject. This approach also has the advantage of supporting individual differences in learning styles. Students bring to the classroom a diversity of interests, levels of preparation, cultural backgrounds and learning styles. Included in our model is a set of powerful software tools that allow data to be captured, abstract concepts to be simulated and sets of data to be visualized. We advocate placing these tools for learning in the hands of each student, not only in the hands of the instructor for recitation.

Cooperative learning is a highly structured, systematic instructional strategy in which students work in small groups toward a common goal. This strategy has been shown to promote active learning, positive student attitudes toward learning and increase student interdependence. Increased interdependence is a positive goal for students because of its effects on student interpersonal skills, teamwork capability and self esteem. While working in teams on a project, students cannot be passive on-lookers; the contribution of each team member is important. (Millis, 1991) Teamwork is also becoming a widely implemented organizational strategy in many work settings, including manufacturing, services and government. Instructional practices should prepare students for working in this type of environment. Our IMDL model allows the instructor to set up groups of students who will work together on an assignment and then share their results with the group.

Comparison of IMDL Environment with Existing Distance Learning Environments

Traditional distance learning programs have most often replicated the teacher lecture model of education. These environments primarily utilize one-way satellite transmission of video signals, with limited student feedback via phone calls. Interaction between the teacher and students is limited and interaction between students at different sites is non-existent. The technology is not at fault; the problem lies with the types of activities to which it is being applied. This technology may be appropriate for delivering messages to multiple sites when interaction is not desired. However, it lacks any significant interaction that might foster teacher "coaching" of students, or learning conversations between teachers and students or students and their peers.

Other technologies used in distance education offer more interaction but support either video and audio interaction, or data ihteraction, but not both modes. Each mode has unique characteristics that allow enhancement of communication but suffer from limitations also.

Video teleconferencing offers 2 way and multi-point video and audio communication between sites. Video's strength lies in its ability to closely mimic "reality." Face to face communication is full of subtle actions and nuances that modify the meaning of the spoken words. Students also may see examples and demonstrations being performed. Unlike a "real" classroom, though, students cannot go to the blackboard and interact with the teacher's example or view other students' work.

Computer conferencing is primarily a means for sharing text or graphic messages that are deferred in time. This allows the sharing of work between teacher and students and students with their peers. Verbal communication is transmitted in text form, also deferred in time. This environment lacks the rich communication capability of video, because of the communication limitations of text and graphics. Sharing of a common data set for collaborative work is also rare in this environment, although the NGS KidsNet, Julyan (1991), does allow students to work with common, aggregated data to interpret acid rain studies.

The IMDL environment model that we have developed combines the rich communication capabilities of 2-way video teleconferencing with real time, synchronous data communications for sharing of computer application "events" between workstations. The level of interaction is quite high and the environment offers the possibility of sharing between teacher and students and students with their peers. The interactions are real-time, not delayed in time. This capability increases student motivation and may provide increased interaction and feedback between students.

Our learning model is a student-centered model; therefore, students and teachers all have the same software applications and databases installed in their desktop workstations. Students may work on their own with the software tools or use on-line tools as references while participating in a class session.

Teachers may use the IMDL environment for lecture when appropriate, or to guide students through exercises performed on their local workstations. Students may share their work with all the other participants and receive feedback. They may also engage students in learning conversations that include passing the control of the session back and forth from teacher to student.

Project Background

The Interactive Multimedia Distance Learning project evolved from discussions between RPI and AT&T about how to use the strengths of AT&T's Bell Labs and RPI's CIUE to collaborate on a project in the domain of computers and communications. AT&T Bell Labs planned to contribute their expertise in communications and networks and CIUE planned to contribute experience in developing multimedia instructional software and managing software development projects, such as CUPLE, the Comprehensive Physics Learning Environment (Wilson, Redish,1992). The CUPLE project integrates hypermedia based computer activities and video material on the same computer screen. The environment also allows for live data acquisition from laboratory interfaces and from video sources. CUPLE has been created by a consortium of universities and is now in the testing stage at over 200 universities. Physics Academic Software, the publishing arm of the American Institute of Physics, is publishing the final version.

From these discussions it was decided that the project would involve re-designing a course from AT&T 's University of Sales Excellence (USE). USE is an internal training and education organization supporting marketing staff in the Business Communication Services division of AT&T. The course chosen for redesign is titled, "How to Make Money Grow on Trees." This course teaches the features of AT&T Advanced 800 Services and how to apply them to customer applications.

Currently, the course is delivered in audio graphic mode. The students attend the course in a training room at their office site equipped with a conference speakerphone, with a large microphone, electronic polling devices and a video blackboard. The students communicate verbally with the instructor using the speaker phone and the AT&T Alliance Call Bridging Service in a multi-point voice conference. All the student sites hear the instructor's lecture, and the student questions from other sites, on their conference phone speaker. The students follow the instructor through the course content material in their Student Guides. The video blackboard is used to display text and graphics screens, with instructor annotation, to supplement the Student Guide materials. Also, students may give answers to multiple choice questions by pressing a button on their electronic polling devices.

We wanted to apply the IMDL environment model to a real life situation. Using our model, we would make the course environment more interactive. In the old version of the course, students could not see their instructor or the other students. They also had no way to share their work with the instructor or other students. The instructional strategy was primarily lecture and the students were only passively engaged in the experience. The IMDL environment model of instruction would also allow students to construct their own understanding of the material by giving them powerful on-line software tools and reference materials that they may access during the course.

We also wanted to investigate how the interactions between teacher and student and interactions between student and their peers change when the learning environment changes from a lecture environment to a highly interactive desktop computer based video conference environment.

Initial Findings from Prototype Testing

In June of 1993, we tested the IMDL environment with live participants. The University of Sales Excellence course that we developed was delivered by an instructor in Cincinnati, Ohio. The student participants were located in Dallas, Texas, Chicago, Illinois and Holmdel, New Jersey. The "students" were actually other AT&T instructors, who were volunteering to participate. This was done for 2 reasons. First, we did not want real student's success in the course to be impeded in any way by any unforeseen problems that developed in the delivery of the course. Second, instructors are accustomed to thinking about teacher-student interactions and we felt that this would give us better feedback.

The participants' reactions might be grouped into 2 areas. The first group of comments were positive about the user interface and software tools. Generally, the students enjoyed the experience. They also found that it had great potential to improve upon other modes of instruction delivery. The second group of comments described the participants' intimidation by the technology employed in delivering the course. The students and instructor felt that they would need some help in getting started using IMDL technology to deliver instruction. This reaction is understandable and may be addressed in the design of the IMDL interface and training materials.

How Will Technological Advances Effect IMDL?

The only thing that is certain is change itself. This couldn't be more true than in the field of educational technology. Our IMDL model is designed to use off-the-shelf technology and to accommodate technological change. We want to be able to port our model to whatever platform
is accepted as a standard in the future.

The pace of technological change in the telecommunications industry is such that the cost barriers to entry are rapidly falling. The costs of the high bandwidth transmission necessary for IMDL may be prohibitive for some organizations and it is certainly difficult to justify for the home. Cable companies and phone companies are competing and collaborating to make high bandwidth transmission universally accessible. This will make implementation of IMDL environments easier to cost justify.

There are other technical hurdles to overcome in the implementation of IMDL environments. These mainly concern better digitization of video and resource management of large libraries of multimedia material (video, graphics, etc.). Developments in these areas are also proceeding well and the implementation of multimedia servers and new video compression algorithms will make the technological hurdles easier to overcome in the near future.

Applications of IMDL

The 1990's are presenting many challenges to institutions of higher education. Private institutions are facing declining enrollments as the number of college age students decreases. They are also facing the need to lower costs as students are finding it increasingly difficult to afford private education. On the other hand, public higher education institutions will probably experience level or increasing enrollments due to many factors. Among these factors are returning adult learners, the shift to more affordable education choices, and geographic population shifts. In addition, all institutions will need to accommodate a more diverse student population; including adult learners, cultural diversity and workforce continuing education.

IMDL will help address these challenges in several ways. Institutions will be able to create a more productive learning environment, with more learning going on in a shorter amount of time. This will address cost issues, as students will be able to complete programs of study more quickly. Students will have access to more effective

learning environments in a greater variety of locations. IMDL will enable instructors to reach out with course materials to locations outside the classroom and off the campus. This will address the needs of all institutions to reach out to a wider student body and enable life long learning for our entire population. In order for our educational institutions to provide more productive learning environments to a diverse student population institutions must share resources and collaborate in the delivery of instruction. IMDL will enable this kind of cooperation.

Finally, and certainly as important, are the needs of our secondary schools. They face a number of challenges for the 90's. Secondary schools have had more difficulty keeping up with technological advancements in industry and higher education. Teachers in secondary schools face isolation from their peers and the need to keep up with education technology. In addition, secondary schools face the familiar problems of lowering costs and providing a more productive learning environment with a lower budget. IMDL environments address these issues by offering the opportunity for teachers and students to reach beyond the classroom to receive instruction, collaborate/interact with peers in learning projects, receive faculty development programs and link to resources not even thought of today. Costs will be the major issue in creating these links, but the investments must be made.

Indications for Further Research

Our work to date has focused a "proof of concept" test of technology and techniques for IMDL. Further work needs to done to study the cognitive and pedagogical implications of learning in distributed classrooms. Our future work will concentrate on further testing IMDL these implications in the delivery of higher education courses, corporate training courses and faculty development workshops. We want to answer questions such as the following:

1. Does IMDL allow instructors to guide students to learning objectives requiring higher cognitive level thinking?

2. Compare the cost effectiveness of instructor led, Computer Assisted Instruction, non-interactive distance learning and IMDL instruction delivery.

3. What kind of cues will best alert users to system status during sessions?

4. What kind of preparation training will make the IMDL environment comfortable to use for the participants?

5. What kind of class activities are best performed locally and what activities are best performed in conference?

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